

Delaware River

Monroe County

American Shad Monitoring, 2022

American Shad represent a highly desirable fishery in the Delaware River during their spring spawning run. This fishery is collaboratively managed by the Atlantic States Marine Fisheries Commission (ASMFC) and the Delaware River Basin Fish and Wildlife Management Cooperative (Co-op), of which the Pennsylvania Fish and Boat Commission (PFBC) is a member of both entities. A suite of long-term monitoring time-series data sets with associated management benchmarks have included relative abundance of juvenile and adult life stages and commercial exploitation, as identified by Co-op members and outlined within the [2022 American Shad Sustainable Fisheries Management Plan \(SFMP\)](#). As described within the SFMP American Shad fisheries are judged sustainable if indices of stock condition remain within the defined benchmarks. Each of these time-series are annually updated and evaluated relative to exceedance of defined benchmark criteria. The SFMP itself is revised on a five-year cycle, with the 2022 SFMP tenure effective from 2022 to 2026. All benchmarks are updated upon the initiation of each future five-year SFMP cycle.

The Co-op proposes six benchmarks for defining American Shad sustainability. Identified benchmarks have been set to respond to any potential decline in stock due to increased exploitation. All benchmarks are viewed as conservative measures. The severity of management action is commensurate with the number of benchmarks exceeded.

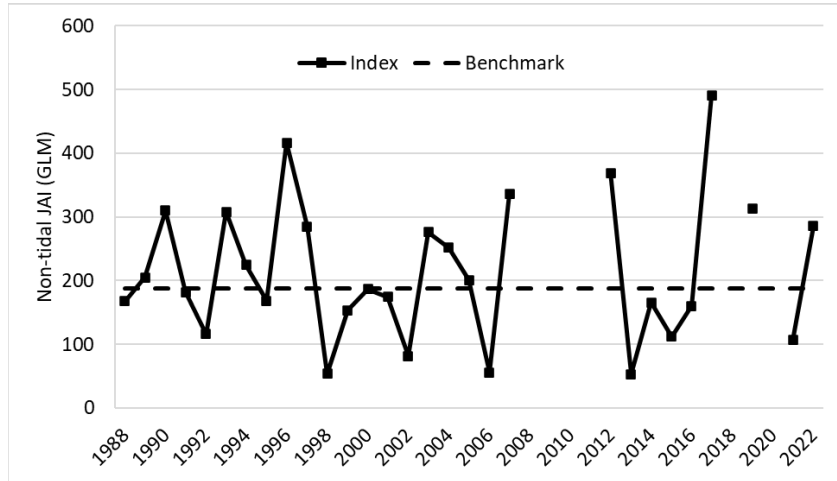
Non-tidal Juvenile Annual Production Index (JAI)

Reinitiated by Co-op members in 2012, this juvenile production index (JAI) was derived from the historical New Jersey Division of Fish and Wildlife (NJDFW) monitoring program, 1988 to 2007. The survey consists of a series of fixed beach seining sites in the Delaware River main stem at Phillipsburg, NJ, Water Gap, NJ, and Milford, PA are conducted once-a-month, from August to October, representing the Delaware Basin JAI above head-of-tide. Essentially this survey tracks the relative abundance of young-of-the-year (YOY) fishes derived from the springtime adult spawning run. The non-tidal JAI is standardized with respect to environmental covariates using generalized linear model (GLM) methodology. The benchmark is based on data from 1988 to 2007 and 2012 to 2019. Sampling was suspended, from 2008 to 2011, 2018 (extreme high flows), and 2020 (COVID-19). Failure is defined as the occurrence of JAI values in three-out-of-five most recent years, which are less than 188 (i.e., the 50th percentile of the historical data). In other words, higher values are indicative of sustainability.

A total of 15,513 YOY American Shad were collected during the 2022 season. The standardized total catch (i.e., 286) ranked 8th highest out of the 29-year time-series (Figure 1). With respect to the management benchmark, data gaps occurred (i.e., 2018 and 2020) and the 2021 JAI (i.e., 106.4) failed the benchmark (i.e., less than 188) within the most recent five-years (i.e., 2018 to 2022). However, 2019 (312.6; 5th highest in the time-series) and 2022 (285.7) JAIs were greater

than the benchmark. Given the missing data and the high rankings of the 2019 and 2022 JAIs, this index was judged as indicative of sustainability for the 2022 season.

Figure 1. Standardized (GLM) annual YOY American Shad total catch within the Delaware River, 1988 to 2022.



Tidal Juvenile Annual Production Index (JAI)

This index is derived from the NJDFW annual YOY Striped Bass beach seining, which also consistently catches YOY American Shad who occupy similar nursery ground habitats, within the upper Delaware Estuary. Only those fixed-sites from Newbold Island to the Delaware Memorial Bridge are included. The JAI index is represented as the annual geometric mean of the catch data. A benchmark was based on data from 1987 to 2019. Failure is defined as the occurrence of JAI values in three-out-of-five most recent years, which were less than 5.81 (i.e., the 50th percentile of the historical data). Like the non-tidal JAI, higher values for the tidal JAI are indicative of sustainability

The 2022 estimate of the tidal JAI was 10.57 ranking 6th highest in the 35-year time-series (Figure 2). Within the most recent five years (i.e., 2018 to 2022), a data gap was introduced for 2020 (i.e., COVID-19); however, the 2019 (0.79) JAI was the only occurrence less than the benchmark. This index was judged as indicative of sustainability for the 2022 season.

Spawning Run Relative Abundance

Annual estimates of the adult spawning run relative abundance are derived from gill netting at Smithfield Beach (RM 218), by PFBC within the Delaware River main stem. This index is calculated as the annual geometric mean of female catch-per-unit-of-effort (CPUE: shad/net-ft-h). The benchmark was based on sampling from 1996 to 2019, with failure defined as the occurrence of annual relative abundance values in three-out-of-five most recent years that were less than 0.52 (i.e., the 50th percentile of the historical data). Higher values are indicative of sustainability for this index.

A total of 222 American Shad (females: N = 197; males: N = 25) were captured during the 2022 season. Sizes varied from 8-inches to 23-inches total length for females and 7-inches to 20-inches total length for males. Unfortunately, within the most recent five-years (i.e., 2018 to 2022), three annual values (2019: 0.21 shad/net-ft-h; 2021: 0.23 shad/net-ft-h; 2022: 0.17 shad/net-ft-h) were less than the benchmark, with the 2022 value representing the 27-year time-series low (i.e., ranked last) (Figure 3). Influences of prolonged high river flow during the 2019 season, unduly influenced the catchability of adult shad, introducing poor confidence in the spawning run index for that year. Yet, this index was judged as failing the management benchmark for the 2022 season.

Figure 2. Geometric means (GM) of annual YOY American Shad total catch within the Delaware Estuary, 1987 to 2022.

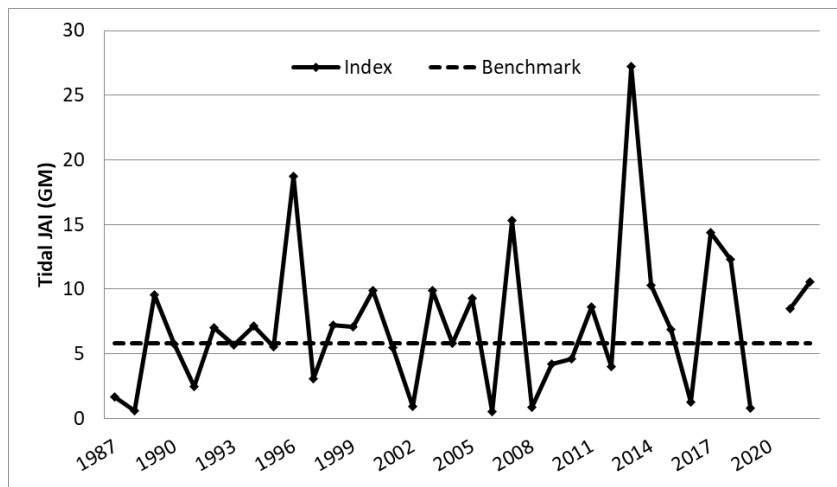
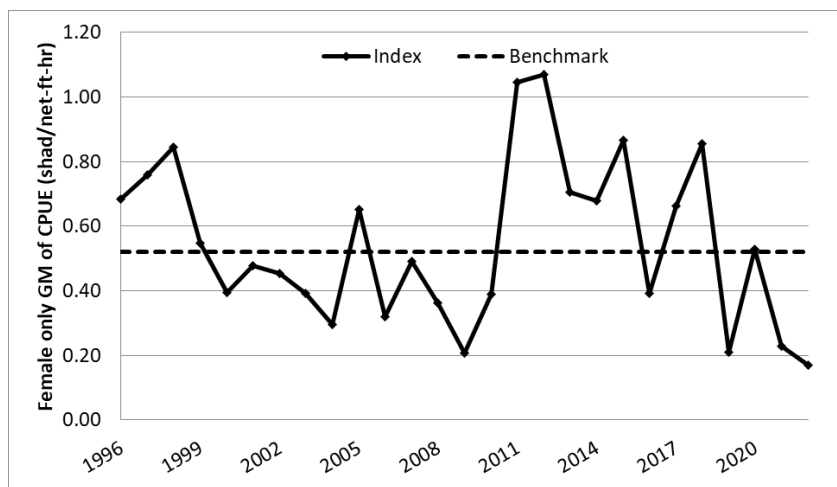


Figure 3. Annual geometric means of catch-per-unit-of-effort for adult female American Shad spawning run at Smithfield Beach (RM 218), Delaware River main stem, 1996 to 2022.



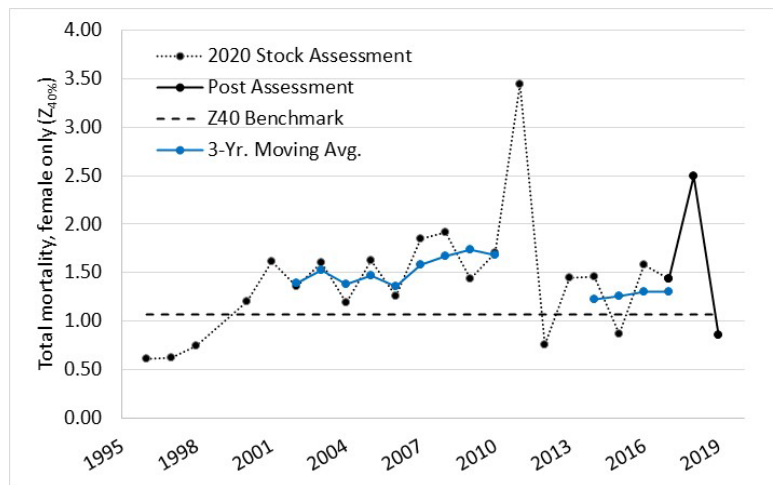
Total Mortality

This index represents the loss of females from the adult spawning population. It is calculated as the adult female total mortality (i.e., $Z_{40\%}$) from the spawning population age distribution. Ages are determined via otolith microstructure of shad collected at Smithfield Beach during the springtime spawning run. The benchmark is based on data from 2005 to 2017 and failure is defined as the three-year rolling average of the most recent years greater than 1.07 (i.e., $Z_{40\%}$). Lower values are indicative of sustainability for this index.

This index was demonstrated to be unsustainable within the Delaware Basin in the ASMFC 2020 stock assessment (Figure 4). Throughout the entire time-series, the three-year rolling average was greater than the benchmark. In response, Co-op members implemented restrictions by 33% for both commercial landings and recreational harvest beginning for the 2023 season.

[Specifically, within Pennsylvania, the Delaware River daily creel limit was reduced to two shad per day.](#) The Lehigh and Schuylkill rivers remain catch-and-release only. Co-op members are hopeful this restriction will aid the reversal of female loss to the population. Annual estimates for 2021 and 2022 are pending age estimation of collected otoliths.

Figure 4. Total adult female mortality for American Shad captured at Smithfield Beach, Delaware River, 1996 to 2022.

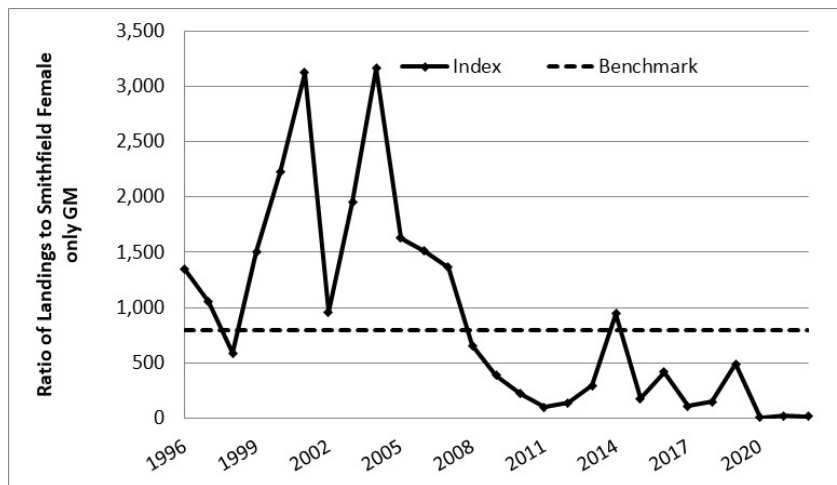


Ratio Commercial harvest to Spawning Run Relative Abundance

Commercial fisheries exist within Delaware Bay that are known to harvest adult American Shad during the springtime as they return to their natal waters. The intent of this index is to address the relative loss of shad from the Delaware River population, based on survivors after the fisheries. It is expressed as the ratio of total combined pounds of adult shad reported landed in the states of New Jersey and Delaware to the adult female-only spawning run relative abundance as characterized by the Smithfield Beach index, divided by 100. The benchmark is based on data from 1996 to 2019. Failure is defined as the occurrence of annual values in three-out-of-five most recent years greater than 799 (i.e., the 50th percentile of historical data). Lower values are best for this index.

Approximately a combined total of 588-pounds of shad were reported being landed for the 2022 season to the states of New Jersey and Delaware. Half (i.e., 50%) of the total landings (i.e., 294-pounds) are attributed as representative of the Delaware River stock. The 2022 estimate was 16.9, ranking the lowest for the 27-year time-series (Figure 5). Within the most recent five-years (i.e., 2018 to 2022), index values for all years have remained less than the benchmark. This index was judged not in exceedance for the 2022 season.

Figure 5. Ratio of combined commercial landings from the Delaware Bay and lower Delaware Estuary to Smithfield Beach index, 1996 to 2022.



Mixed Stock Landings

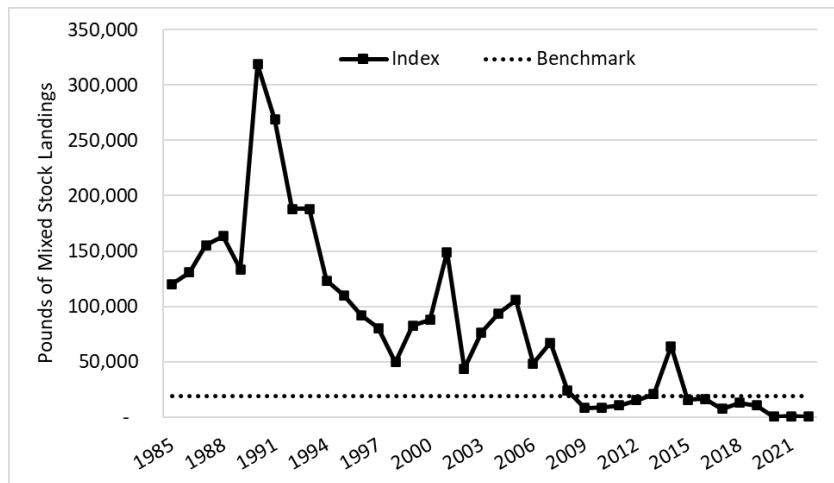
American Shad occurring in the Delaware Basin are represented by both Delaware River origin fish as well as fish from multiple other coastal river stocks. The commercial fisheries operating within the Delaware Bay and Delaware Estuary land shad from these mixed stocks in addition to the Delaware River stock. The Co-op is sensitive to the potential impacts on East Coast shad stocks from Delaware Bay and Delaware Estuary commercial fisheries. Assignment of 50% (i.e., half) of all commercial landings reported to the states of New Jersey and Delaware are attributed as representative of the mixed stock component, based on updated genetic findings. Thus, the other half of the combined total landings are considered Delaware River stock. The 38-year time-series encompasses, 1985 to 2022, with the benchmark based on data from 1985 to 2019. Failure is defined as the occurrence of values in two (2) consecutive years (i.e., most recent) greater than 18,505-pounds (i.e., the 25th percentile of historical data). Lower values are best for this index.

A combined total of 588-pounds of shad were landed from the Delaware Bay and Delaware Estuary, with 294-pounds considered as mixed stock during 2022 (Figure 6). Within the most recent last two years (i.e., 2021 to 2022), both the 2021 (i.e., 488-pounds) and the 2022 landings were less than the benchmark. This index was judged not in exceedance for the 2022 season.

Assessment of Delaware River American Shad Sustainability

Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring defines a sustainable fishery as one that will not diminish potential future stock reproduction and recruitment. Indices of female total mortality and female spawning run relative abundance exceeded their associated benchmarks. Corrective management action was enacted for the 2023 season by Co-op members in response to the failed female total mortality index. Given the newness of this measure and the uncertainty of the 2019 female spawning run relative abundance as representative of that year's estimation of relative abundance, further potential management action considerations will follow the 2023 female spawning run relative abundance index measurement. Monitoring and sustainability evaluation for all indices will continue in 2023.

Figure 6. Mixed stock landings of American Shad landings from the Delaware Bay and Delaware Estuary, 1996 to 2022.



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